SEDATION OF PEDIATRIC PATIENTS IN MAGNETIC RESONANCE IMAGING

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CHAPTER I: INTRODUCTION

Background

Magnetic resonance imaging (MRI), a non-invasive radiographic test, is used to aid the diagnosis of diseases and abnormalities. It requires a cooperative and immobile patient for approximately 30-90 minutes (Tobin, Spurrier, & Wetzel, 1992). Immobilizing a child for this length of time is a challenge. History has shown that most young children are unable to remain motionless for the extended length of time necessary to perform a MRI examination without sedation (Bisset & Ball, 1991). Providing the sedation is the responsibility of the anesthesia provider.

Gaining intravenous access by venipuncture is the first priority of the anesthesia provider. The anxiety and fear of the needle perceived by the pediatric patient may result in an uncooperative child and a dissatisfied radiologist. The challenge to anesthesia providers is keeping the child immobilized during the MRI scan without compromising respiratory or hemodynamic status. A sedation regimen that is planned must provide hemodynamic and respiratory stability for the patient.

Planning pediatric sedation

Sedation of the pediatric patient is a process carefully planned by the anesthesia provider. Achieving cooperation and immobility of the patient are the main concerns for the radiologist while performing the MRI scan. Any sudden movements by the pediatric patient can result in an inconclusive scan. Hubbard, Markowitz, Kimmel, Kroger, and Bartko (1992) demonstrated that the failure of sedation to enable completion of an examination is more frequent with MRI scan than with other imaging modalities. A study by Slovis and associates (1993) concluded that after repeated failed MRI scans, it is

advisable to use the most effective drug regimen with the fewest side effects to provide sedation for pediatric patients. The problem for the anesthesia provider is developing a sedation regimen that renders immobility of the pediatric patient without compromising their respiratory or hemodynamic status. At a midwest medical facility near Dayton, Ohio, such a regimen has been developed and implemented.

A midwest medical facility regimen

At this midwest medical facility, the use of an intramuscular combination of ketamine, midazolam, and atropine with a propofol infusion is used for pediatric sedation for magnetic resonance imaging (Worrell & McCune, 1993). First used as an intravenous sedation, the ketamine, midazolam and atropine combination is now given intramuscularly by a certified registered nurse anesthetist (CRNA). Coordination of the plan of sedation involves the anesthesia provider, the radiologist and the parent of the infant or child. Together they ensure an effective and safe sedation regimen for the patient. Pediatric sedation for MRI scans is very important as these scans are used more frequently for disease diagnosis in these patients.

The dramatic growth in the volume and types of interventional radiology procedures performed during the past five to ten years has been documented by many institutions (Mueller, Wittenberg, Kaufman & Lee, 1997). The success of MRI scans in further diagnosing diseases has lead to its increased use with patients of all ages. Along with this growth, there has been an increase in the demand for, and use of, intravenous analgesia or conscious sedation for these types of procedures. Trained individuals with knowledge of pediatrics and the effects of sedating medications on this patient population are essential in the MRI setting.

Specifically trained individuals, (CRNAs or anesthesiologists), at each MRI site should determine the type of monitoring and sedation to be utilized with pediatric patients (Shellock, 1995). Nurse anesthetists, along with the anesthesiologist, share that responsibility at the medical facility. This facility instituted the intramuscular regimen previously described with the expert knowledge of a certified nurse anesthetist who not only recognized the need for effective and safe pediatric sedation, but also addressed the need of the child s emotional and physiological stress unique to pediatric patients (Worrell & McCune, 1993).

Sedation of the pediatric patient can be a tedious process for the anesthesia provider. Immobility of the patient is the main concern for the radiologist while performing the MRI scan. The hemodynamic and respiratory status of the pediatric patient is the main concern for the anesthesia provider. At the facility, an experienced CRNA who is knowledgeable in the side effects of ketamine, midazolam and atropine with pediatric patients, developed her own formula for an intramuscular administration of a midazolam, ketamine, and atropine mixture with a propofol infusion for continued sedation.

Medications

Ketamine is often a drug chosen by anesthetists because it provides anesthesia, amnesia, and analgesia when administered (Stoelting & Miller, 1994). This drug s peak affects can be seen within two to four minutes after the drug is administered. A patient can be awake but calm depending on the amount of drug given. However, side effects of dissociative behavior and increased airway secretions could endanger the patient. The administration of an anticholinergic like atropine to decrease secretions is advisable since

it decreases the side effect of ketamine (Worrell & McCune, 1993). The CRNA at the midwest medical facility initially utilized a sedation regimen initiated by her colleagues. This regimen combined ketamine and midazolam given intravenously to pediatric patients prior to MRI scans.

Midazolam is a benzodiazepam, exerting most of its effects on the nerve endings of the brain and spinal cord (Stoelting & Miller, 1994). Adverse effects such as respiratory depression and a decrease in blood pressure can occur. The immature nervous system of pediatric patients makes them vulnerable to these effects. Midazolam, given in combination with ketamine, decreases the dissociative side effects of ketamine without depressing the patient s respirations. MRI scanning times vary, frequently requiring longer sedation. Propofol, an adjunctive drug to the regimen, is often used to provide additional sedation for longer cases. It was chosen because of its rapid onset of effect and recovery time, and antiemetic effect (Levati, et al., 1996). Propofol has a peak onset of action within 30 to 60 seconds, a fact which makes it ideal for aiding in sedating pediatric patients. This drug combination of ketamine, atropine, and midazolam given intramuscularly, with a propofol infusion, provides a safe and effective sedation regimen that makes the MRI scan a success and less stressful to the pediatric patient. The various effects of these medications on the hemodynamics of the patient requires stringent attention throughout the scanning process. Monitoring the effects of the sedation requires the use of safe equipment and is the responsibility of the anesthesia provider.

Monitoring equipment

Monitoring the pediatric patient during sedation for MRIs is essential to anticipate potential side effects of sedative drugs (http://www.springnet.com/ce/ce/ce966tx.htm).

Monitoring equipment in close proximity to the magnet may malfunction because of the strength of the high magnetic field (Tobin et al., 1992). Visual aids such as cameras, pulse oximetry, and non-invasive blood pressure cuffs allow monitoring necessary to evaluate the respiratory and hemodynamic status of the patient (Worrell & McCune, 1993).

At the midwest medical facility, the nurse anesthetist coordinates her equipment needs with the radiologist to ensure the safety of the patient, anesthetist and radiology personnel. Shellock, Lipczak, & Kanal (1995) report that several hazards are associated with the performance of patient monitoring during MRI examinations. Physiologic monitors that contain ferromagnetic components like transformers and outer castings can be strongly attracted by the static field used by the MRI system. The large magnet used for imaging produces the static field. Unlike household magnets, this magnet has a force of attraction so strong that pens and barrettes become missiles in its proximity. In addition for potential damage to the MRI system, this poses a serious hazard to patients and MRI technicians (Holshouser, Hinshow, & Shellock, 1993).

Some electronic monitors produce their own radio frequency pulses and degrade image quality of the MRI image (Jorgensen, Messick, Gray, Nugent & Berquist, 1994). Providing effective sedation decreases incidence of patient immobility, which is the most common cause of degraded image quality. The pharmacological properties of ketamine, midazolam, and atropine provide the sedation levels needed to render the patient immobile, while maintaining hemodynamic and respiratory stability (Worrell & McCune, 1993).

Pharmacology of ketamine.

Ketamine is a phencyclidine derivative that produces a central dissociation between the thalamus and limbic systems (Stoelting, 1987). It is a white, crystalline compound soluble in water and produces a clear, colorless solution when mixed (Young, 1971). Ketamine s lipid solubility, a measure of how effective the drug diffuses to the blood and brain, is 10 times that of thiopental and after intravenous injection, was found to have an onset of 30 to 60 seconds and duration of 10-15 minutes (Loo, Thomas, Tan, Yeo & Sia, 1997). This character of the drug makes it ideal for sedation and rapid recovery. Ketamine causes an increase in heart rate and systemic blood pressure as well as copious amounts of oral secretions. The anticholinergic effects of atropine decrease the production of secretions, which could obstruct the airway.

Emergence is the time of recovery from the effects of a drug. Emergence delirium is an agitated state of recovery from a drug that often requires the use of restraints (Stoelting & Miller, 1994). Emergence delirium occurs more frequently in older children sedated with ketamine alone (Sussman, 1994). However, this same literature shows that occurrences of emergence delirium are greatly decreased when given in combination with midazolam. Emergence is the time of recovery from the affects of a drug. Emergence delirium is an agitated state of recovery from a drug that often requires restraint (Stoelting & Miller, 1994). Emergence occurs more frequently in patients greater than eight years old who have been sedated with ketamine alone (Sussman, 1994). However this same literature shows that events of emergence delirium are greatly decreased when given in combination with midazolam.

Pharmacology of midazolam.

Midazolam is a benzodiazepine, which exerts its pharmacological effects by enhancing the chloride channel gating function of the inhibitory neurotransmitter gamma aminobutyric acid, GABA (Stoelting & Miller, 1994). The majority of benzodiazepine receptors are contained within the cerebral cortex. Like ketamine, midazolam is a highly lipid soluble medication, resulting in rapid entrance into the central nervous system followed by redistribution to inactive tissue sites. The combined use of midazolam and ketamine alone was found to be safe and effective for minor dental procedures (Roelofse, Joubert, & Roelofse, 1996) however excess oral secretions in a supine patient, such as a pediatric on an MRI table, is hazardous. The combined use of ketamine and midazolam can produce increased oral secretions that could block the airway. This risk necessitates the need for an anticholinergic like atropine.

Pharmacology of atropine.

Atropine is an anticholinergic which produces an anti-salivary effect, thereby, decreasing the side effects of ketamine induced increased secretions (Stoelting & Miller, 1994). Anticholinergics also prevent bradycardia, a decrease in heart rate that may occur with the administration of propofol. The combination of midazolam, ketamine and atropine in conjunction with the intravenous infusion of propofol, inhibits the side effects of each drug if individually given.

Pharmacology of propofol.

Propofol is a lipid soluble substituted isopropylphenol that produces rapid induction of anesthesia followed by rapid awakening in four to eight minutes after the infusion is discontinued (Stoelting & Miller, 1994). Propofol is frequently used alone

during MRI examinations. According to Levati et al. (1996) during the MRI scan, anesthesia was considered satisfactory when the patient did not move, pulse oximetry and end tidal carbon dioxide levels were maintained in the normal range and blood pressure and respiratory rate were maintained at baseline values. This data is reassuring to the anesthesia provider since propofol is known to depress the blood pressure and ventilation.

Significance of the Problem.

The task of providing effective sedation while maintaining the protection of the pediatric patient s respiratory and hemodynamic status is not a new challenge to anesthesia providers. Vade, Sukhani, Dolenga & Habisohn-Schuck (1995) studied the use of chloral hydrate sedation of children undergoing CT and MRI imaging. They reported that this regimen was effective despite the fact that 20 percent of the children in their study developed respiratory problems. The use of high dose oral chloral hydrate accounted for mild hypoxia in several children in a study by Greenberg, Faerber, Aspinall, & Adams (1993).

Cote (1994) reported that the protective airway reflexes are lost with deep sedation. This situation requires greater vigilance and monitoring in children than in adults. The American Academy of Pediatrics established and implemented guidelines to follow with pediatric sedation. These guidelines include frequency of assessing vital signs and equipment needed for monitoring the sedated pediatric patient. Adherence to these guidelines has accounted for the decreased number of adverse outcomes related to pediatric sedation.

Kennelly, Salitorre, and Barnes (1996) reported that the guidelines established by the American Academy of Pediatrics for monitoring and managing pediatric sedation for diagnostic and therapeutic procedures were implemented for all sedation performed at Rush Children s Hospital, Chicago, Illinois. After implementation of these guidelines, a demonstrated decrease in adverse reactions was apparent. The personnel responsible for administering and monitoring these sedations were registered nurses trained in pediatric advanced life support. The nurse anesthetist at the facility uses these guidelines and her knowledge of pediatric sedation to provide a safe and efficacious regimen that is one solution to the problem of pediatric sedation for MRI scans.

Problem

Patients must remain immobile for magnetic resonance imaging. The majority of adult patients are able to remain immobile, however, this is very challenging for pediatric patients. Pediatric sedation is necessary to achieve this immobility while maintaining the heart rate, respirations, and pulse oximetry levels at the patient s baseline values.

Purpose

The purpose of this study was to explore the combination sedative of ketamine, midazolam, and atropine administered intramuscularly and determine if it is safe and effective for pediatric patients undergoing magnetic resonance imaging.

Research Questions

1. What effect does a mixture of midazolam, ketamine, and atropine administered intramuscularly have on the pediatric patient s heart rate, respirations, and pulse oximetry readings?
2. Can the intramuscular administration of a combination of ketamine, midazolam, and atropine provide enough sedation for the immobilization required to complete a MRI scan?

Conceptual Framework

This descriptive study was based upon Sister Callista Roy s Adaptation Model (Roy, 1991). According to Roy, nursing is defined as a theoretical system of knowledge, prescribing a process of analysis and action related to the care of the ill or potentially ill person (1991). The nurse anesthetist in this study provides this process through thorough documentation of past medical history and vigilant monitoring throughout the procedure.

Monitoring of the patient s physiological parameters allows the CRNA to assess the patient s ability to adapt to certain stimuli. Based on the patient s adaptation to the stimuli, nursing intervention is initiated. This action is derived from Roy s Adaptation Model, (RAM). The focus of the knowledge for nursing practice is an understanding of the person as an adaptive system (Roy, 1997).

Within the RAM, three stimuli that affect the person s ability to adapt were identified. The first, focal stimulus, is considered as the internal or external stimulus most immediately confronting the person, in the case of this study, intravenous catheter

placement for the MRI scan. Based on perception of this stimulus, a response will occur (Munn & Tichy, 1987). The second stimulus identified is the contextual stimulus. This involves all environmental factors that present to the person from within and without the person but which are not the focus of the person s attention, in this case, staying immobile for the MRI scan. The final stimulus is the residual which includes all those stimuli that surround or are within the person that have an unclear effect on the current situation, or more specifically, the disease process.

Together, these stimuli elicit responses to which the patient may or may not be able to adapt. The regulator is the body system which induces physiological responses through neural, chemical, and endocrine processes (Roy, 1991). The regulator in this study would be the hemodynamic or respiratory system, more specifically, heart rate, respirations, and oxygen saturation. The cognator , the body system that elicits responses through perceptual processing and learning, is the pediatric patient. The ability of this patient to process the stimuli from internal and external may affect the adaptation of the patient.

Monitoring of these areas will alert the CRNA to needed intervention to assist the patient to adapt. Taking into account these stimuli and the effect or potential effect they may have on the patient s ability to adapt to them, the CRNA becomes a vital link between the regulator, cognator and perception of the patient (Phillips et al., 1998). This model has been used in previous pediatric studies, for example: care of an eight year old with leukemia (Wright, Holcombe, Foote, & Piazzo, 1993), care given on a neuroscience unit to pediatrics (Frederickson & Williams, 1997), responses to

venipuncture (Bournaki, 1997), and adjustment of adolescents with cystic fibrosis (Russell, Reinbold, & Maltby, 1996).

Roy s Adaptation Model is viewed as an excellent model for pediatric nursing research (Betz & Beal, 1996). Roy has even suggested that models such as her own provide a perspective for research, separating the area to be studied and guiding the research questions to be asked (Tolson & McIntosh, 1996). Because the RAM focus is on the dynamics of the adaptive responses to stimuli by the person, this model is most appropriate for this study.

This research design was descriptive and retrospective. The independent variables were the intramuscular administration of ketamine, midazolam, and atropine and the administration of a propofol infusion. The dependent variables were heart rate, respirations, and pulse oximetry reading after drug administration. A t-test analysis was used to compare the difference between the means of the groups. The sample of 51 patients was randomly selected and to reflect the age group of three months to 15 years of age.

Assumptions

1. All patient charts provided accurate baseline vital signs for the required preoperative exam.
2. All the MRI scans required a propofol infusion for prolonging sedation.
3. The regimen for sedation described was utilized by all anesthesia providers involved with MRI scans at the midwest medical facility..
4. All patients received an intramuscular dart combination of ketamine, midazolam and atropine.

Limitations

1. The age spans of the sample ranged from three months to 15 years of age. Different levels of development and coping were expected with age differences.
2. Over the counter medications may be utilized by patients. These medications, such as opiods narcotics, bronchodilators, and barbiturates can provide additional sedation to the patient.
3. This retrospective study was a review of charts. No standardized recordings of vital signs before or after intramuscular medication administration could be applied.

Definitions-Conceptual and Operational

1. Stimulus/stimuli- any internal or external force which produces a positive or negative effect on the individual.
2. Vital signs- the patient s heart rate and respirations per minute.
3. Pulse oximetry saturation- the saturation level of oxygen within the capillary beds of the fingers as measured by infrared waveforms that display numeric readings between the values of 20 through 100 percent.
4. Hemodynamics- that which pertains to the heart rate.
5. Respiratory status- breathing rate per minute.
6. Regulator- the subsystem which induces physiological responses through neural, chemical, and endocrine processes.
7. Cognator- the subsystem which elicits responses through perceptual/information processing, learning, judgement, and emotion processes

Summary

Nursing uses a holistic approach to patient care. Stressors such as venipuncture and IV placement, separation from parent, and unfamiliar sounds can affect the adaptation of pediatric patients to their environment. Magnetic resonance imaging requires the cooperation and immobility of the patient for long periods of time. At the midwest medical facility near Dayton, Ohio, pediatric sedation regimen of a combination of ketamine, midazolam, and atropine administered intramuscular is used. A review of the literature shows safety and efficacy of pharmacologically similar drug combinations. Chapter II will discuss these drugs.

CHAPTER II: LITERATURE REVIEW

Introduction

Pediatric sedation techniques have changed over the years. Twenty years ago male infants receiving a circumcision sucked on bourbon sponges for sedation, today regional anesthetics are used (LtCol J. Ikirt, personal communication, 19 February 1998). Safety of the patient is the paramount concern in all pediatric sedations. According to the guidelines established by the American Academy of Pediatrics, monitoring of the patient should take place before, during and after administration of sedative agents, especially in settings outside the operating room (Committee on Drugs, 1992).

Pediatric sedation for diagnostic and therapeutic procedures, performed outside the operating room setting, have increased dramatically over the last 10 years (Hollman, Elderbrook, & VanDenLangenberg, 1995). Anesthesia providers often administer sedative agents to pediatric patients undergoing diagnostic studies. Some of the responsibilities of the anesthetists lie in their ability to choose a safe and effective drug for the pediatric patient. Within this chapter, a brief review of chloral hydrate s history as a standard in pediatric sedation will be explored. In addition, a review of the literature of various sedative drugs used in pediatrics, such as midazolam, ketamine and propofol, will be discussed. The primary focus will be the drug affect on the patient s heart rate, respiratory rate and oxygen saturation.

Chloral Hydrate History

For many years, different medications have been used in the sedation of pediatric patients. Chloral hydrate is one drug that has gained favor among physicians. Malis and Burton (1997), two pediatric otolaryngologists, described chloral hydrate as the standard

agent for pediatric sedation. In their study of its effectiveness for pediatric sedation, they found that oral chloral hydrate was the most frequently used initial medication among 31 radiologists surveyed. Morgan and Mikhail (1996) describe chloral hydrate as a relatively safe and effective drug that could lead to respiratory depression if repeated dosing is required.

Vade, Sukhani, Dolenga, and Habisohn-Schuck (1995), in a study of the use of chloral hydrate for sedation of pediatric patients undergoing MRI scanning, concluded that mild hypoxia (SaO2, 90-95%) seen in the chloral hydrate-only group differed little from the chloral hydrate and hydroxyzine group, at values of 9% and 5%, respectively. These investigators, however, did not explain what constituted a successful MRI scan. Mild hypoxia of the same degree was also seen in a study by Greenberg et al. (1993) while evaluating the safety and efficacy of high dose chloral hydrate sedation for children undergoing MR imaging. The age span of the children in this study are similar to the sample to be evaluated at the midwest medical facility and should provide a good correlation to findings. Frush and Bisset (1997) concluded that chloral hydrate can be used in pediatric sedation, but that the radiologist should balance the pros and the cons, such as gastric irritation with high doses, before administering the drug.

Ineffective amounts of medication are one of the major drawbacks of chloral hydrate. Unlike ketamine, midazolam and atropine, chloral hydrate cannot be given intravenously or intramuscularly. This drawback limits chloral hydrate use to oral administration. When it is given orally, children may vomit. The amount of drug remaining in the stomach may not be effective in providing sedation. Greenberg et al. (1994), radiologists at St. Christopher s Hospital for Children, found that oral

thioridazine, an antipsychotic drug with mild antiemetic effects, administered with chloral hydrate, was beneficial in relaxing the difficult-to-sedate child undergoing MRI scanning, however, repeated dosing was required for those patients who vomited. The problem with repeating oral doses is that one cannot be absolutely sure of the amount of medication given.

In a study by Malviya,Voepel-Lewis, and Tate (1997), children sedated with chloral hydrate who experienced inadequate sedation and failed procedure were six years older than those who experienced adequate sedation. These findings reflect the greater effectiveness of chloral hydrate in children under two years of age (Katzung & Trevor, 1996). The willingness of the child to receive chloral hydrate limits its use. Egelhoff, Ball, Koch and Parks (1997) showed that transient respiratory depression (oxygen saturation 10% below baseline) was seen in infants receiving oral chloral hydrate and pentobarbital, however, they do not state what the baseline values of oxygen saturations were. Although response of chloral hydrate may be unpredictable and variable, other drugs such as meperidine and midazolam for sedation of pediatrics are not without fault.

Meperidine and Midazolam

Unlike chloral hydrate, midazolam and meperidine are two drugs that can be administered intravenously and intramuscularly, thus enhancing the complete uptake of the medication by the patient. According to Martyn (1993), the oral route is the easiest and most common way to administer a drug to pediatrics, however, he states that intramuscular injections are beneficial once adequate muscle mass is present. At the University of Southern California School of Dentistry, Malamed, Quinn and Hatch (1989) found that intramuscular (IM) and intravenous (IV) midazolam sedation were

more beneficial to their pediatric patients. Of the 31 patients in the study, all ranging in age from 19 months to 11 years, 30 of the cases were successful with one patient needing referral for general anesthesia. Only four patients had pulse oximetry readings fall to 90% or below and heart rates that increased transiently to 140 and above. The investigators failed to report if the unsuccessful case had inadequate muscle mass, a fact that they had reported was the key to intramuscular administration. Terndrup et al. (1991) analyzed the effectiveness of IM meperidine, promethazine and chlorpromazine in the sedation of pediatric emergency department patients. They concluded that this drug combination was effective and safe with only clinically mild but statistically significant changes occurring in respiratory rate, heart rate, systolic blood pressure and Glasgow Coma Scale. Contradictory to this study is the research by Petrack, Marx and Wright (1996) which revealed that intramuscular ketamine has a much faster onset and results in a more rapid discharge from the pediatric emergency department than the results seen with a combination of meperidine, promethazine, and chlorpromazine. Ketamine is one of the drugs in the sedation regimen at the facility which has gained favor among the anesthesia and radiology providers.

Forestner (1987) states that the pediatric cocktail , which usually consists the same drug combination used by Terndrup and others (1991) is a favorite of radiologists because it produces deep sedation within 30 minutes of IM injection. On the other hand, Moscona, Ramon, Ben-David and Isserts (1995) concluded, while comparing different sedation techniques for outpatient rhinoplasty, that certain limitations and risks lay with the use of standard pediatric lytic cocktails and that newer, short-acting agents such as midazolam, propofol, fentanyl and ketamine should be used instead. This opinion is

shared by Taylor, Vine and Hatch (1986) who stated, while evaluating the effectiveness of intramuscular midazolam in small children undergoing diagnostic procedures, that midazolam is an effective premedicant for children when administered intramuscularly, rectally, intranasally or orally. An assumption of the author s proposed study is that all the patients will require a propofol infusion for their MRI scan. The above mentioned studies will provide a background for expected findings. While Sacchetti (1995) concluded that although drugs, such as benzodiazepine and pentobarbital, do nothing to inhibit pain, they are very effective as complete sedative-hypnotics. Drugs such as ketamine provide analgesia as well as sedation for pediatric patients.

Ketamine administration

Ketamine is a phencyclidine analogue that can produce rapid induction of general anesthesia with sedation and analgesia, especially when given intramuscularly (White, 1996). A review of literature shows effectiveness of ketamine administered alone and in combinations with other agents.

Investigating the respiratory interactions of ketamine and morphine, Bourke, Malit, and Smith (1987) found that ketamine alone caused the carbon dioxide response curve to shift to the right, but did not change the slope of the curve, similar to opioids, indicating less of a respiratory effect on the pediatric patient. As stated previously, one of the major side effects of ketamine is emergence delirium which this study did not address. Marx et al. (1997) concluded that a drug combination of ketamine and midazolam given intravenously was more effective at producing sedation with a faster onset and recovery than a combination of midazolam and meperidine. In this study hypoxia (77.8%), hypotension (55.6%), and tachycardia (55.6%) were the most prevalent adverse reactions

with the meperidine and midazolam combination and clinically insignificant with the ketamine and midazolam combination. This study was more definitive of the criteria for adverse effects of vital signs so one could undoubtedly see the differences between the two drug regimens.

Research continues to show the effectiveness of combining ketamine and midazolam for reducing the delirium emergence and dissociative effects of ketamine when given alone. Anderson and Lerman (1994) and Warner, Cabaret and Velling (1995) reported a decrease of the psychological side effects of ketamine when given orally with midazolam. In similar studies, Louon and Reddy (1994) reported the same results for pediatric patients undergoing computerized axial tomography (CT), who were administered the drugs nasally. As stated before, oral administration of a drug to pediatric patients can not guarantee complete absorption of the medication.

Weksler, Ovadia, Muati, and Stavis (1993) evaluation of nasal ketamine for pediatric premedication identified this route of administration as an alternative for young children aged two to five years of age. Weights and ages of these children were similar to those of the previous studies of Louon and Reddy (1994). Again, emergence delirium has to be expected in a dose of ketamine administered alone and neither study addressed it. Sekerci, Donmez and Okten (1996) evaluated the effects of oral ketamine given to 43 children undergoing ophthalmic surgery and found that 33% of the study group had incidences of nausea and vomiting, but no one displayed emergence delirium. These authors failed to mention an obvious limitation to their study, which is,: with such a high incidence of vomiting, the patients did not experience emergence delirium because they probably did not receive the full, if any part, of the drug dose. However, Donohue and

Dinten (1992) reported that large doses of ketamine and midazolam given orally predisposed children to emergence delirium after radiographic procedures; the children intermittently stared blankly into space and screamed loudly for two minutes before settling down.

The rectal administration of ketamine and midazolam shows a faster onset than other routes of administration except for the intravenous route. Beebe et al. (1992) evaluated the effectiveness of preoperative sedation with rectal midazolam and ketamine given singly or in combinations to young children in need of an intravenous catheter. The study showed that patients separated easily from their parents and remained immobile for IV placement. This study reflects one of the facility s goals for their pediatric sedation regimen and that is to decrease separation anxiety. Oxygen saturations remained above 90% in 92% of all the study groups; the other 8% had transient decreases. In a similar study, Lokken et al. (1994) saw that midazolam alone caused a decrease in the blood oxygen level but when given with ketamine, produced clinically insignificant but statistically significant decreases in the oxygen level of pediatric patients having dental treatment performed. This study further supports the facility s use of a drug combination which includes the ketamine and midazolam. Still, some health care providers find that the rapid onset of intravenous ketamine is more favorable.

Ketamine and Midazolam

The use of ketamine and ketamine midazolam combinations administered intravenously consistently renders faster sedation than other routes. Cotsen, Donaldson, Ueijima, and Morello (1997) studied the efficacy of ketamine sedation in children for interventional radiologic procedures and reported that the average induction time for the

IV sedation route was 45 seconds as compared to 4 minutes for the IM route. While this study helps answer the question whether of a combination of ketamine, midazolam and atropine provides adequate sedation, it does not indicate how much additional time was needed to place the IV. The facility s use of the IM drug dart of ketamine, midazolam and atropine before IV placement provides a cooperative patient and a fast IV placement. Again, this study showed respiratory adverse effects were transient and cardiovascular changes minimal in all the patients. In a two part series evaluating ketamine sedation for pediatric procedures in the emergency room, Green, Nakamura and Johnson (1990) concluded that IM ketamine was sufficient for sedation, but later Green and Johnson (1990) agreed with Hollister and Burn (1974) that intravenous sedation is more desirable for prolonged procedures. Patients at the facility receive a propofol infusion in addition to the drug dart for MRI scans.

During the evaluation of the efficacy and safety of intravenous midazolam and ketamine as sedation for therapeutic and diagnostic procedures for pediatric patients on oncology wards, Parker, Mahan, Gingliano and Parker (1997) showed no serious respiratory and cardiovascular complications. In addition, only 2% of the entire sample experienced transient drops in their oxygen saturations. Likewise, Okamoto, Duperon, and Jedrychowski (1992) chose the same drug combination because of ketamine and midazolam relatively short duration of action on pediatric patients receiving dental examinations. Not only did the children separate from their parents easier, but they also were much more cooperative than prior to receiving the premedication. At the midwest medical facility, anesthesia providers report a fast discharge from the recovery room and attribute it to the short duration of action of ketamine, midazolam and propofol.

Research has shown that few health care providers show a hesitancy of using ketamine unless it is contraindicated. In a review of pediatric conscious sedation, Wertz (1994) and Ramoska (1991) concluded that because of its ability to increase cerebral blood flow and thus intracranial pressure in a compromised cranium, ketamine should not be used in the emergency department with unconfirmed head injuries. The patient population for the proposed study are outpatients or scheduled in patients who have been screened for contraindications for ketamine use. Pruitt, Goldwasser, Sabol and Prstojevich (1995) chose glycopyrrolate, an anticholinergic agent, to combine with ketamine because its quarternary amine structure prevents it from crossing the blood brain barrier and exacerbating the dissociative effects of ketamine thus prolonging recovery. Although a tertiary amine that can cross the blood brain barrier, the midwest facility uses an atropine dose of 0.02mg per kg and its effect on patient will be evaluated in this study. In spite of the faster onset of action when given intravenously, other investigators have found that due to the longer duration of MRI scans, techniques that incorporate the use of narcotics, barbiturates and ketamine, singly or combined, have not provided adequate sedation and that the use of intravenous propofol was more beneficial (Lefever, Potter, & Seeley, 1993).

Propofol

In a study of the pharmacokinetics of propofol, Saint-Maurice, Cockshott, Douglas, Richard and Harmey (1989) reported that the use of propofol produced anesthesia faster because of the larger central compartment in children than in adults and that the rapid metabolism of this agent discontinues its anesthetic effect faster. This characteristic of propofol is confirmed by Burke and Pollock (1994) when explaining that

their eight years of using continuous infusion of propofol renders better long term sedation without clinically significant adverse effects. At the facility, propofol is the drug of choice for pediatric patients requiring MRI scans because scans must last longer than the sedative effects of the drug dart used.

The adverse effect causing greatest concern when administering propofol is apnea. Broennele and Cohen (1993), anesthesiologists at Children s Hospital in Philadelphia, Pennsylvania, says that the frequent episodes of apnea produced by continuous propofol infusion makes it unsafe for use with individuals with critical airway and ventilatory issues; infants are an example. In their study, end tidal carbon dioxide and oxygen saturation did not fall below baseline but supplemental oxygen was used. Safety is the primary concern of the anesthesia staff at the facility and, therefore, an evaluation of their pediatric sedation plan is most appropriate to gain further knowledge about the drugs effect on the patient. Whether propofol is considered a primary sedation or secondary method to barbiturates, benzodiazepines and ketamine, it continues to be part of standard pediatric sedation.

Summary

This literature review shows multiple sedative-hypnotics, their different routes of administration and their efficacy and safety for sedation of the pediatric patient. All comment on the effects of various drugs on the pediatric patient s hemodynamic status and respirations but also show that no definite sedation routine for these patients is believed to be better than the other. Ketamine, atropine, midazolam, meperidine and chloral hydrate are sedation agents that each display advantages and disadvantages to their use. The use of propofol has shown favor among physicians for longer MRI scans.

To ensure that anesthesia providers administer safe and efficacious sedation to pediatric patients, further research is necessary. The pediatric sedation regimen at the midwest medical facility will be evaluated for its safety and efficacy of patients receiving MRI scans. In the following chapter, a research plan and methodology to study a pediatric sedation regimen will be described.

CHAPTER III: METHODOLOGY

Introduction

The design of this study was descriptive. The data were collected through a retrospective chart audit of 51 pediatric patients requiring sedation for magnetic resonance imaging (MRI). Data were collected to evaluate the heart rate, respiratory rate, oxygen saturation and blood pressure before and after the intramuscular administration of ketamine, midazolam and atropine combined in a syringe. A similar method of data collection was used by Bournaki (1997) to evaluate the effects of venipuncture of adolescent children. In this study, the sample consists of infants, toddlers and adolescent children.

Sample

A sample of 51 pediatric patient records, between the ages of three months to 15 years was chosen. This age group represented the population of pediatric patients obtaining MRI scans at the midwest medical facility. A sample of 51 subject provided a power level of 80% with a critical effect size of 0.38, for a two-tailed test of significance at an alpha level 5% (Kramer & Thiemann, 1987). The patients records were selected but not divided into three age groups. Each chart's baseline vital signs recorded in the preoperative phase (just prior to administration of the medication combination) and in the operative phase (the set of vitals at the peak of injection medications or two to four minutes) were obtained from the record and recorded on the data tool. A percentage of all, if any, changes in the vital signs was recorded and analyzed statistically using a t-test analysis.

Measurement

The vital signs were obtained from the patient s medical record. Using the data collection sheet designed by the principle investigator, the heart rate, respiration and pulse oximetry reading were recorded. After collection of the data, a comparison of the vital signs before and after the drug combination of ketamine, midazolam and atropine was performed. The comment section was used to indicate whether the patient was unable to complete the MRI scan or not. The certified registered nurse anesthetist (CRNA), who administered the medication to the patient, validated the recorded values on the data collection sheet. This task was accomplished by confirmation of the presence of the recorded-data symbol on 51 records, a symbol which was agreed upon by the principle investigator and the CRNA. Reliability of the data recorded was obtained by the CRNA using the data collection list by the principal investigator.

Protection of Human Rights

Guidelines were followed by the Internal Review Board (IRB) of the Uniformed Services University of the Health Sciences and midwest medical facility. The subject s hospital number was not needed, just the vital signs of the patient. A symbol recognized only by the principal investigator and the CRNA giving the medication was used to signify that the chart had been used in the study. Records pooled for the study did not leave the hospital s outpatient records section. This increased the protection of confidentiality of the patients.

Plan for Data Analysis

The data were statistically summarized in frequency distributions and summary measures, including means, standard deviations, and standard errors, using SPSS software (1997). Cross-tabulations were explored, using a t-test analysis. In addition,

significance tests was performed on differences found in dependent variables, as, for example, a comparison of heart rate before and after administration of medication. Statistical significance of changes in the dependent variable was assessed at the 0.05 alpha level. Appendix A provides an example of the tool to be used in data collection and Appendix B provides the legend table for the collection tool.

CHAPTER IV: DATA ANALYSIS

Introduction

In this descriptive study of pediatric sedation used in conjunction with Magnetic Resonance Imaging (MRI) a total of 51 charts were reviewed retrospectively to analyze the effects of an intramuscular injection of ketamine, atropine and midazolam on the heart rate, respiratory rate, blood pressure and oxygen saturations of pediatric patients. The charts were obtained from the pediatric outpatient clinic of a midwest medical facility in Ohio. The data collection tool described in chapter three (See Appendix A) was used to record the data and to verify reliability. Magnetic resonance imaging (MRI) is a radiologic scan that requires the patient to remain immobile for several minutes. This task is very difficult for the pediatric patient without some form of sedation. At the facility where this data was collected, all of the pediatric patients had a MRI scan that was completed without interruption.

Originally, the researcher planned to show blood pressure variations of pediatric patients after the intramuscular dart, however, blood pressure readings were not recorded in the records. This variable was then deleted from the collection tool. Respirations, heart and oxygen saturations before and after the intramuscular injection were recorded. In addition to these vital sign analyses, the inclusion barbiturates, bronchodilators and opioid narcotics were recorded on the data collection sheet; these classes of drugs can especially effect the heart rate and respirations. The use of intravenous propofol was used as an adjunct to the intramuscular injection because of its quick onset and rapid elimination from the bloodstream (Stoelting & Miller, 1994). Unfortunately, two thirds of the charts reviewed had missing propofol doses; therefore total propofol amounts

could not be reliably gleaned from the record, and were excluded from data collection. Validity of the data recorded was made by the CRNA described earlier in the proposal. She compared her data list with the data collected and verified a 100% match of data recordings.

Study Sample Demographics

Data from the charts of pediatric patients ages three months to 15 years of age were collected. The mean age was four years. The most frequent diagnosis found out of five diagnoses prevalent was developmental (See Table 1).

Table 1.

Diagnosis of Patients

	Frequency
Oncological	5
Trauma	6
Developmental	29
Neurological	7
Hematoma	4

The variables to be analyzed, heart rate, respirations and oxygen saturations, were recorded on the collection tool. Vital signs before intramuscular injection were not consistently recorded as noted by the varying sample sizes in Table 2.

Table 2.

Frequencies of Dependent Variables

RECORDINGS	Heart Rate	Respirations	Oxygen saturation
Before medication	39	32	13
After medication	51	51	51

Oxygen saturation recordings before medication had 38 missing values, the largest inconsistency of the three vital signs. Three of the charts without heart rate, respirations and oxygen saturations had statements such as "...patient crying" and "..very playful without signs of breathing difficulties". All 51 charts had all three vital sign recordings after medication administration.

Forty-five percent of the patients had regularly prescribed medications taken before receiving the intramuscular dart for MRI scanning. Other medications prescribed to the patients belonged more frequently to the barbiturate group, with opioid narcotics and bronchodilators second and third, respectively (See Table 3.)

Table 3.

Other Medications Prescribed for 23 of the 51 Subjects

	Frequency	Percent based on N=51
Barbiturates	14	27.5
Opioid Narcotics	6	11.8
Bronchodilators	3	5.9

Analysis of Data

Data analysis was performed using t-test with statistical significance of $p < .05$. Two-tailed t-test was performed before and after intervention to compare dependent variables; heart rate, respirations and oxygen saturations after medications. Table 4 represents a description of the dependent variables, their minimum and maximum levels, the mean and standard deviations of each.

Table 4.

Descriptive Statistics of Dependent Variables

Variable	Min per minute	Max per minute	Mean	Std. Deviation
HR after med	60	150	114	23
SaO2 after med	96	100	99	1
Resp after med	10	35	23	6

T-test analysis performed on heart rate recorded before and after medication showed no significance (2-tailed) of .08 with a degree of freedom (df) of 38. These statistics show that there was a variation in heart rate before medications (lowest 72 and highest 152) and heart rate after medication (lowest 60 and highest 150).

Unlike the findings with heart rate, oxygen saturations did not show significant variation after intramuscular medications. Supplemental oxygen of four to six liters per minute was used on all patients after sedation with the intramuscular injection.

Finally the respirations recorded before and after the intramuscular dart showed no significant deviations in the rate. The lowest respirations per minute before and after the medication were 16 and 10, respectively. Differences in normal values of age groups

were considered. Some records showed that the patient was crying before the dart was administered thereby reflecting a much higher respiratory rate than expected for age.

Analysis of the data using the two-tailed t test (p=.05) showed no statistical significance with the pairing of two groups, the oxygen saturation before and after medications (significance=.34) and the respirations before and after medications (significance=.90). According to Burns and Grove (1997), statistical values can occur at either end (tails) of a normal curve. Statistically significant data is found between the two extremes of the curve (See Table 5).

Table 5.

Two-tailed test for HR, SaO2, and Respirations before and after medication administration

	Sig. (2-tailed)	t-test
Hr before and after med	.08	1.77
SaO2 before and after med	.34	-1.00
Resp before and after med	.90	-.13

Summary

Throughout the review of the 51 pediatric charts, completion of the MRI scan was found to take place without interruption. Recorded use of propofol was found in 29 of the 51 charts, however, because of inconsistency with the charting of the dose used for infusion and dosing used for boluses, no conclusion as to the effectiveness could be drawn. According to Cote (1994), resting respiratory rate of patients between the ages of three months to three years is typically found between 16-25 breaths per minute (bpm),

three to 10 years between 18-20 bpm and ages 10 to 15 years of age between 14-20 bpm. Because the respirations were not consistently charted before medications, this overlap in resting respiratory rate was not seen. The oxygen saturation of all ages was between 96-100% before and after medication. The heart rates before medication was recorded for 39 of the 51 patients and recorded for all 51 patients for heart rates after the medication given. With this study information , certain conclusions can be made about the effectiveness of the intramuscular injection of midazolam, atropine, and ketamine with the supplemental use of a propofol infusion for gaining immobilization of the pediatric patient for magnetic resonance imaging. Chapter V will discuss the conclusions and give suggestions for further research of this type of study.

CHAPTER V: CONCLUSIONS

Overview of the Study

A retrospective study was conducted to collect information about pediatric patients who received an intramuscular injection of ketamine, atropine, and midazolam for sedation during magnetic resonance imaging (MRI). Pediatric sedation has been used frequently to gain intravenous access of the pediatric patient and reduce separation anxiety from parents but the question of safety of this sedation continues under close scrutiny.

Magnetic resonance imaging is a non-invasive radiographic test used to aid in the diagnosis and follow up of diseases and abnormalities. These scans require a cooperative and immobile patient during imaging. Pediatric patients at the midwest medical facility receive an intramuscular injection dart and a propofol infusion during MRIs to gain immobility and cooperation. The purpose of this study was to examine the safety and efficacy of the intramuscular injection combination for pediatric patients undergoing MRIs.

Characteristics of the Study Sample

A total of 51 charts were identified that contained the types of subjects needed for this study: pediatric patients, ages three months to 15 years old, and administration of the ketamine, atropine, and midazolam dart MRI scanning. The mean age was four years. One patient was mistakenly identified as a three-month-old on the anesthesia record but in fact was two months old according to her birth date. This record was deleted from the list and another eligible chart was identified. The pediatric charts are stored in the pediatric clinic, a department of the midwest medical facility but separate building not

easily accessed during a regular workday. The MRI scanning took place at the main hospital therefore the anesthetic record had to travel through inter-hospital mail to the pediatric clinic. This procedure took several weeks to months.

Magnetic resonance imaging (MRI) is often used follow up on certain disease processes. Charts reviewed were grouped into five categories frequently diagnosed and followed in pediatric patients by MRI scanning. These categories were as follows: oncological, trauma, hematoma, developmental, and neurological. There were five patients identified in the oncological group or 9.8%. These patients had varying degrees of head, neck, thoracic and spinal tumors that were being treated by radiation and/or chemotherapy. The trauma group numbered 6 of 51 patients or 11.8%. This category of patients had trauma from the birthing process which often included head hematomas, therefore, with the exception of two patients suffering trauma from vehicular accidents, they were also included in the category of hematomas, four or 7.8% of the sample. A similar sharing of categories existed between the developmental group, 56.9% (29/51), and the neurological group, 13.7% (7/51). The patients in the developmental group often had neurological problems such as seizure disorder, spastic muscle contractions and short spinal cords. Developmentally, these patients showed decreases in speech, skeletal growth and motor skills. Seizure disorders were also present among the oncological group, especially those tumors involving the brain, however, because the primary diagnosis was of an oncological nature, those patients were not included in the neurological category.

The patients had varying diagnosis, which often manifested different symptoms among the sample. Seizure disorders, whether a result of oncological or neurological

disease processes, were often treated with barbiturates or opioid narcotics. Barbiturates and their derivatives, such as mysoline, decrease exaggerated neuronal activity associated with seizures (Stoelting & Miller, 1994). Fourteen of the 51 patients were a part of this category and represented the largest group of other medications prescribed. Second to this category were patients prescribed opioid narcotics, representing six of 51 patients. The researcher expected this category to show a higher representation of the overall sample since opioids relieve pain and pain is very often associated with oncological disorders. Noted during the investigation were 28 charts that had no other medications recorded in the records. The final category of medications was inhalants or bronchodilators that helped relax smooth bronchial muscles and increase airway diameters. Only three patients of the 51 were recorded to have this type of medication prescribed.

Effect of Intramuscular Ketamine, Atropine, and Midazolam on Vital Signs

Sedation was successful in aiding in the completion of MRI scanning of pediatric patients at the midwest medical facility. Sedation, of any kind, can however produce certain changes in the hemodynamics and respiratory status of the patients receiving it. From the data collected in this study, the intramuscular injection of ketamine, atropine, and midazolam was given just prior to scanning.

Heart rates after medication

Heart rates were not decreased after administration of the intramuscular injection. The mean heart rate before the medication was109 beats per minute (bpm) and the mean heart rate after medication was 114 bpm. An explanation for these values lay in the fact that atropine, an anticholinergic drug that increases heart rate, is a part of the sedation regimen. Also influencing the heart rate findings is the age of the patient. Those patients that were aged 10 through 15, (4/51), showed the smallest increase in heart rate, four to eight beats, after medication. Perhaps these patients also showed less anxiety because of the increase in age and coping mechanisms. Referring back to Roy's Adaptation Model (1991), coping mechanisms increase with age to a certain level. Among the patients ages three to 10 years, a larger increase in heart rates by 11-20 bpm were found, after medication administration. Finally, in the three months to three years category, a decrease in heart rate of 10-12 bpm was identified after administration of the drug. This decrease may be attributed to an exaggerated increase heart rate due to crying before drug administration. In summary, the overall effect of the intramuscular dart on heart rate was not negative. No patient became hemodynamically compromised due to a decreased heart rate. Again, some of the values for heart rates before medications were not present in the charts reviewed. Bronchodilators also can increase the heart rate. Three patients were prescribed this type of medication in the study. Similar findings on the patient's respiratory status were also noted.

Respiratory Rates After Midazolam, Atropine, and Ketamine

Respiratory rates also vary among different age groups. Because of smaller lung size and less functional residual capacity, patients under the age of one year have higher respiratory rate to maintain enough oxygen for exchange. In the charts reviewed, 32 of 51 charts reviewed (62.7%), had recorded respiratory rates before drug administration. Among these charts, respiratory rate range was 16 to 40 breaths a minute (bm) with a mean of 22 bm. Opioid narcotics may depress respiratory status, however, the six patients prescribed opioids narcotics had no respiratory rates recorded before drug administration, therefore, the effect of the intramuscular dart administration on respirations could not be determined for them or the 19 charts missing this piece of information. Of the remaining 32 charts with recorded values, a mean respiratory rate after intramuscular drug administration was 23 breaths a minute. Therefore, the administration of the intramuscular dart showed no significant influence on the patients' respiratory status. The oxygen saturation (SaO2) appeared to have little changes after administration of the ketamine, atropine, and midazolam IM dart. An explanation of these findings is discussed in the following paragraph.

Oxygenation (SaO2) after ketamine, atropine, and midazolam IM dart

The SaO2 represents the peripheral arterial oxygenation status of the patient and is measured by pulse oximetry. Several factors can influence the values. The pulse oximeter derives the calculations from pulsatile arterial capillaries. Vasoconstriction, hypothermia and hypotension can decrease the signal measured by the pulse oximeter. The charts reviewed had no blood pressures recorded therefore, hypotension was not considered as an influencing factor. Temperatures of the patients were also not recorded.

A high temperature could cause vasodilatation while a low temperature could cause vasoconstriction thus increasing and decreasing arterial pulsatility, respectively.

SaO2 before intramuscular drug administration was recorded for 13 (25%) of the 51 charts reviewed. The SaO2 range was 97 to 100% with a mean of 98.5%. Oxygen saturations after medication were recorded for all 51 charts reviewed and had a range of 96 to 100% with a mean of 99%. All of the patients received supplemental oxygen via face mask of four to six liters per minute after sedation with the dart which helped maintain adequate oxygen delivery to the lungs. This fact probably accounts for the insignificant variations in oxygen saturations before and after drug administration.

Completion of MRI scanning with the IM dart of ketamine, atropine, and midazolam

The question of whether a single intramuscular administration of ketamine, atropine, and midazolam provide enough sedation to complete a MRI scan was asked in chapter one. If the scan was of short duration, less than 30 minutes, the IM dart should be all the medication required. Also, 14 of the 51 patients were prescribed barbiturates, a drug class known to have sedative effects, and should have shown more sedation with the addition of the IM dart. However, the chart review showed that all of the patients had intravenous catheters inserted after the dart and had propofol administered during the scans. The scanning times ranged from 28 minutes to 191 minutes. Although a scan time of 28 minutes should have been enough time for just the IM dart alone, the researcher failed to consider time needed to transfer patient to the MRI scanning table and the placement of monitoring equipment on the patient. This time alone could amount to at least 10 to 20 minutes. Also, the patients could have been agitated during transfer from the preparation gurney to the scanning table thus delaying the start time of scanning.

The propofol doses of all the patients were not recorded. According to the CRNA at the medical facility, a 100 millimeters (mls) bag of normal saline had 10 mls of saline removed and 10 mls of propofol of a 10 milligram (mg) solution injected, thereby giving a final concentration of 1mg per ml. With the use of a microdrip intravenous tubing apparatus which delivered 60 drops (gtts) per minute, one could calculate the milligrams delivered if drops per minute were known. Forty of the 51 charts reviewed had missing propofol doses, therfore no assumptions were made about the amount of propofol required to complete the scan. However, it was clearly evident through the review that the intramuscular administration of ketamine, atropine, and midazolam was not sufficient to complete the MRI scan.

Conclusions

This study has described the use of intramuscular ketamine, atropine, and midazolam for pediatric sedation. The results of this study indicate that this regimen is a safe and effective one.

(1) The heart rate, respiratory rate, and oxygen saturation before and after intramuscular injection of ketamine, atropine, and midazolam showed no statistically significant differences.

(2) All of the patients required the use of a propofol infusion to complete the MRI scan.

Future Study

During the collection of data for this study, the researcher found limitations that could be avoided in a prospective study. Setting strict guidelines for vital sign recording would provide more information about the patient before any intramuscular medications

are used. A standardized recording method of propofol dosing should also be implemented. Finally, a prospective study would eliminate the tedious task of locating records and missing anesthesia sheets.

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APPENDICES

A. Data Collection Tool

B. Data Collection Tool Legend

APPENDIX B

Legend.

Record Collection Spreadsheet

ID	DX	Ag	Rce	Wt	Bhr	Brr	Bbp	BO2	Med	Ahr	Arr	Abp	AO2	FiO2	TP

Key ID = patient s hospital number
DX = patient s diagnosis, see below
Ag = age in years
Rce = race, see below
Wt = weight in kilograms
Bhr = heart rate per minute before medication
Brr = respiratory rate per minute before medication
Bbp = blood pressure before medication
BO2 = oxygen saturation before medication
Med = ketamine 3mg/kg+midazolam 0.07mg/kg+0.02mg/kg IM, see below
Ahr = heart rate per minute after medication
Arr = respiratory rate per minute after medication
Abp = blood pressure after medication
AO2 = oxygen saturation after medication
FiO2 = percent oxygen used
TP = type of oxygen device used, see below

Coding:

Race
1. Caucasian
2. Black
3. Hispanic
4. Asian
5. Other

Gender
1. Male
2. Female

Medication
1. Given
2. Not given

Diagnosis
1. Oncological
2. Trauma
3. Hematoma

Oxygen type
1. Face mask
2. Nasal cannula
3. Intubated
4. Nothing used

Plan for Data Analysis